INSTRUCTION MANUAL

REGULATED POWER SUPPLIES

LJS-10-V SERIES

TEST EQUIPMENT COPY

MP MASTER
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LAMBDA

LAMBDA ELECTRONICS MELVILLE, L. I., N. Y.

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FOR

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LJS-10-V SERIES

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This manual provides instructions intended for the operation of Lambda power supplies, and is not to be reproduced without the written consent of Lambda Electronics. All information contained herein applies to all LJS-10-V models unless otherwise specified.

LAMBDA ELECTRONICS MELVILLE, L.I. N.Y.
MAIN PLANT TELEPHONE: 516 MYrtle 4-4200

IM-LJS-10-V

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SPECIFICATIONS AND FEATURES

DC OUTPUT — Voltage regulated for line and load. See table I for voltage and current ratings.

TABLE I
VOLTAGE AND CURRENT RANGES

MODELS	VOLTAGE RANGE	MAXIMUM CURRENT (AMPS) AT AMBIENT TEMPERATURE		
		50°C	60°C	71°C
LJS-10-V-5-OV	5 ± 5%	10.0	8.0	5.5
LJS-10-V-6-OV	6 ± 5%	8.3	6.6	4.5
LJS-10-V-12-OV	12 ± 5%	4.2	3.4	2.3
LJS-10-V-15-OV	15 ± 5%	3.3	2.6	1.8
LJS-10-V-20-OV	20 ± 5%	2.5	2.0	1.4
LJS-10-V-24-OV	24 ± 5%	2.1	1.7	1.2
LJS-10-V-28-OV	28 ± 5%	1.8	1.4	1.0

Current range must be chosen to suit the appropriate maximum ambient temperature. Current ratings apply for entire voltage range.

REGULATED VOLTAGE OUTPUT

Regulation ..... 0.4% line or load with input variations from 187-265 or 265-187 volts AC and load variations from no load to full load.

Ripple and Noise ..... 10mV RMS, 50mV peak-to-peak for LJS-10-V-5-OV, -6-OV models; 15mV RMS, 100mV peak-to-peak for LJS-10-V-12-OV, -15-OV, -20-OV, -24-OV, and -28-OV with either positive or negative terminal grounded.

Temperature Coefficient ..... Change in output voltage 0.03%/°C max.

Remote Programming

External Resistor ..... Nominal 1000 ohms/volt output.

Programming Voltage ..... One-to-one voltage change.

Remote Sensing ..... Provision is made for remote sensing to eliminate effect of power output lead resistance on DC regulation.

REMOTE ON-OFF CONTROL — The DC output of all LJS-10-V power supplies can be turned on and off remotely by means of digital command or switch closure.

Digital Command Logic Level	0 to +5 volts (logic "0" for ON, logic "1" for OFF)
Switch Closure	"Close" for ON, "open" for OFF
Loading	1.6 ma sinking required. (TTL compatible)

STORAGE TIME — 16 ms min. at full rated current, maximum rated output voltage, and 105 VAC input.

OVERSHOOT — No overshoot under conditions of power turn-on, turn-off, or power failure.

INPUT

AC Input	187-265 VAC at 47-440 Hz. Input power: 68 Watts*. For operation at frequencies above 440 Hz, consult factory.

*With output loaded to full current rating.

INPUT FUSE — Fuse F1 protects the input wiring to the power supply. Overload of power supply does not cause fuse failure.

OVERLOAD PROTECTION

Electrical	Automatic electronic current limiting circuit, limits output current to a preset safe value. Automatic current limiting protects the load and power supply when external overloads and direct shorts occur.

OVERVOLTAGE PROTECTION — All LJS-10-V models include fixed built-in overvoltage protection circuits which prevent damage to the load caused by excessive power supply output voltage. See table below for overvoltage protector firing ranges.

MODEL	OVERVOLTAGE PROTECTOR TRIP-POINT RANGE (VOLTS)
LJS-10-V-5-OV	6.3 — 6.9
LJS-10-V-6-OV	7.1 — 7.7
LJS-10-V-12-OV	13.3 — 14.1
LJS-10-V-15-OV	16.5 — 17.5
LJS-10-V-20-OV	22.1 — 23.5
LJS-10-V-24-OV	26.5 — 28.1
LJS-10-V-28-OV	30.9 — 32.9

INPUT AND OUTPUT CONNECTIONS — Terminal block on front of chassis. Reed-Prince no. 2 screwdriver is required for terminal screws.

OPERATING AMBIENT TEMPERATURE RANGE AND DUTY CYCLE — Continuous duty from 0°C to 71°C ambient with corresponding load current ratings for all modes of operation.

STORAGE TEMPERATURE (non operating) — -55° C to +85° C

VDC ADJ. Control — Voltage adjust control permits adjustment of DC output over entire operating range.

GUARANTEE — 5 year guarantee from date of shipment . . . materials and labor.

PHYSICAL DATA

Size	1-25/32" x 4-3/4" x 9-1/16"
Weight	3.0 lbs. net
Finish	Gray, FED. STD. 595 No. 26081

MOUNTING — One surface with tapped mounting holes can be utilized for mounting this unit. All LJS-10-V power supplies must be mounted with top facing up and in a horizontal plane. Refer to figure 10 for mounting details.

THEORY OF OPERATION

GENERAL

The Lambda power supply consists of an input circuit; internal power supply and starter circuit; clock circuit; dead-time circuit; trigger circuit; pulse width modulator; soft-start circuit; steering circuit; voltage error amplifier; current limiter circuit; remote ON/OFF control circuit; inverter; output rectifier and overvoltage protection circuit.

The circuit arrangement is shown in block diagram form in figure 8. The circuitry is discussed with reference to the block diagram and the schematic diagram.

FUNCTIONAL DESCRIPTION

Input Circuit

Single phase AC input power is applied to the input rectifier CR1-CR4, C5, C6 via EMI suppression network L1, L2, C3, L3, C4. Fuse F1 protects against internal power supply circuit failure.

Internal Power Supply Circuit

The starter circuit CR5, CR6, R2, C6 and Q1 applies input power to the internal power supply consisting of Q6, Q7, Q8, CR15, CR16, C8, C9, C10, R19, R20 and R21, whenever input power is initially applied or when a no-load condition exists at the output after initial turn-on Feedback bias supply "A" CR11-CR14 and R15 applies power to the internal power supply from the 20 KHz inverter. The internal power supply, a linear power supply, provides 28.8 VDC at the emitter of Q6.

Clock Circuit

The clock circuit consisting of Q9-Q12, CR17-CR24, R24-R34, C11-C16, and T2 functions as the master oscillator and the source of DC power to the control circuitry. The waveform at the collector of Q10 and Q12 is square, with a 50% duty cycle in periods of 50 microseconds.

Control Circuitry

The pulse width modulator consisting of A3, R40, R41, CR35, C25-C27, is supplied triggered pulses by trigger circuit CR29-CR34, R35-R37, A1 and A2. Bias supply "B" CR25-CR28 and C19 provides 5 VDC to A1, A2 and A3 and to driver circuit transistors Q14 and Q15. The steering circuit, which consists of A1 and A2 converts single-phase pulses from the pulse width modulator to two phase pulses which are fed to driver circuit Q14, Q15, R58, C29 and T3, which, in turn, applies the pulses to switching transistors Q2-Q5 in the inverter. Dead-time circuit R35, R36 and C18 creates non-conducting dead-time for inverter switching transistors Q2-Q5. Soft start circuit transistor Q13 prevents voltage overshoot when the unit is remotely turned on via a remote turn-on signal applied to terminals RV1 and RV2.

Voltage Error Amplifier

The voltage error amplifier consists of A4, C33, R73, R74, CR41, CR42 and R75, reference voltage diode CR45 and C35, R76, R78, R77 and output voltage sensing network R79, VR4, R82, R83, R81 and C44. The programming current, 1 mA, used in the sensing network, is determined by R83.

Current Limiter Circuitry

The current limit circuitry consists of: buffer amplifier A5, CR36, CR37, R60, R61, C30; current sampling circuit SH0, R68; reference voltage network R64-R66, VR3, CR38, CR44 and amplifier A4, CR39, CR40, C31.

The buffer amplifier acts to change the polarity of the line-drop voltage between the load and the output side of SH0 with unity gain. R68 serves to sum the voltage drop across SH0 and the line and between the load and the input side of SH0 to A-4. The reference voltage is set by adjustment of VR3 through summing resistor R67 and serves to limit overcurrent conditions in the output of the supply.

The amplifier compares the reference voltage with the current sampling voltages and is combined with the voltage error amplifier signal through the action of Q17.

Remote ON/OFF Control Circuit

The remote ON/OFF control circuit A6, C37, CR46-CR50, Q17, R85 and R86 controls unit operation by means of an external ON/OFF control signal, which is generally compatible with TTL voltage levels, supplied to terminals RV1 and RV2. Terminals RV1 and RV2 are isolated from the input line and the unit by means of photo isolator A6.

When RV1 and RV2 are open circuited or are supplied high TTL voltage, a transistor contained in A6 turns off and one of three inputs to A2 goes to a low voltage level of TTL, which causes the inverter to shut down.

Inverter

The inverter, a full bridge circuit consists of four switching power transistors Q2-Q5. When Q2 and Q5 turn on, switching current flows through the primary of T1 in one direction and in the next half period of the cycle Q3 and Q4 turn on and Q2 and Q5 turn off and switching current then flows through the primary of T1 in the opposite direction.

Output Circuit

Positive and negative pulses supplied by the secondary of T1 are rectified by full-wave rectifiers CR51 and CR52; are filtered by a filter network and EMI suppression network: L4-L6, C41, C42, C43 and then supplied to the output.

Overvoltage Protection Circuit

The overvoltage protection circuit consists of two sections, one part, a current transformer circuit consists of the current transformer and a hybrid OV crowbar module MP-1. When the output voltage reaches the trip-point of hybrid overvoltage module MP-1, the module fires, crowbarring the output of the supply to a safe level. The second part of the circuit consisting of SCR, CR41, R45-R47 and C27, uses the output voltage signal generated by the current transformer to turn on SCR, which, in turn, crowbars logic circuitry of A2 that causes the inverter to shut down.

OPERATING INSTRUCTIONS

BASIC MODE OF OPERATION

This power supply operates as a constant voltage source provided the load current does not exceed the rated value at 50° C. For continuous operation, load current must not exceed the rating for each ambient temperature. When rated load current is exceeded, voltage decreases towards zero and the current at short circuit is held to a safe value.

CONNECTIONS FOR OPERATION

NOTE: Make all connections to the unit before applying input power.

Ground Connections. The Lambda power supply can be operated either with negative or positive output terminal grounded. Both positive and negative ground connections are shown in the diagrams for all suggested output connections illustrated in this manual.

Connection Terminals. Make all connections to the supply at the terminal block on the front of the supply. Use a Reed-Prince no. 2 screwdriver on terminal screws. Apply input power to input terminals; always connect the ungrounded AC or DC lead to the bottom terminal.

The supply positive terminal is brought out to terminal +V. The supply negative terminal is brought out to terminal -V. Recommended wiring of the power supply to the load and selection of wiring is shown in figures 1 through 9. Selection of proper wiring is made on the basis of load requirements. Make all performance checks and measurements of current or voltage at the front output terminals. Connect measuring devices directly to terminals or use the shortest leads possible.

Remote on-off control is brought out to terminal RV1 and terminal RV2. Either digital command or switch closure can be used for on-off control. Logic "0" or "close" for ON and logic "1" or "open" for OFF. When digital command is used, RV2 should be connected to the incoming signal ground. Maximum command voltage is +24 volts. Proper remote on-off control connection is shown for all suggested output connections illustrated in this manual.

SUPPLY LOAD CONNECTIONS

Connections for Operation as a Constant Voltage Source

The output impedance and regulation of the power supply at the load may change when using the supply as a constant voltage source and connecting leads of practical length are used. To minimize the effect of the output leads on these characteristics, remote sensing is used. Recommended types of supply load connections with local or remote sensing are described in the following paragraphs.

Refer to figure 1 to determine voltage drop for particular cable length, wire size and current conditions. Lead lengths must be measured from supply terminals to load terminals as shown in figure 2.

Local Sensing Connection, Figure 3. Local sensing is the connection suitable for applications with relatively constant load or for applications with short power output leads.

Remote Sensing Connection, Figure 4. Remote sensing provides complete compensation for the DC voltage drops in the connecting cables. Sensing leads should be a twisted pair to minimize AC pick-up. A 2.5 mf elect., capacitor may be required between output terminals and sense terminals to reduce noise pick-up.

Programmed Voltage Connections, Using External Resistor, Figure 5. Discrete voltage steps can be programmed with a resistance voltage divider valued at a nominal 1000 ohms/volt change and a shorting-type switch as shown in figure 5. When continuous voltage variations are required, use a variable resistor with the same 1000 ohms/volt ratio in place of the resistive voltage divider and shorting-type switch. Use a low temperature coefficient resistor to assure most stable operation.

Before programming, adjust programming resistor for zero resistance and set voltage adjust control to the minimum rated output voltage. Output voltage of programmed supply will nominally be minimum output voltage plus 1 volt per 1000 ohms.

As shown in figure 5, voltages can be programmed utilizing either local or remote sensing connections, as desired.

Programmed Voltage Connections Using Programming Voltage, Figure 6. The power supply voltage output can be programmed with an externally connected programming power supply. The output voltage change of the programmed supply will maintain a one-to-one ratio with the voltage of the programming supply. If the output voltage control of the programmed supply is set to minimum output voltage, output voltage of the programmed supply will be minimum output voltage plus voltage of programming supply.

The programming supply must have a reverse current capability of 1.1ma. minimum.

Alternatively, when supplies with less than 1.1ma. reverse current capability are used, a resistor capable of drawing 1.1ma. at the minimum programming voltage must be connected across the output terminals of the programming supply. This programming supply must be rated to handle all excess resistor current at the maximum programming voltage.

Connections For Series Operation, Figure 7.

The voltage capability of LJS-10-V power supplies can be extended by series operation. Figure 7 shows the connections for either local or remote sensing in a series connection where the voltage control of each unit functions independently to control the output.

A diode, having a current carrying capability equal to or greater than the maximum current rating of the supply, must be used and connected as shown in figure 7. The diode blocking voltage should be at least twice the maximum rated output voltage of the supply. See table I, of SPECIFICATIONS AND FEATURES, for power supply current and voltage ratings.

OPERATION AFTER PROTECTIVE DEVICE SHUTDOWN

Fuse Shutdown. Fuse will blow when the maximum rated current value for the fuse is exceeded. Fatigue failure of fuses can occur when mechanical vibrations from the installation combine with thermally induced stresses to weaken the fuse metal. Many fuse failures are caused by a temporary condition and replacing the blown fuse will make the fuse protected circuit operative.

Overvoltage Shutdown. When the power supply output voltage increases above the overvoltage limit, the overvoltage protection circuit will short circuit output of the supply and shut down inverter operation. After eliminating the cause(s) for overvoltage, resume operation of the supply by momentarily interrupting the AC input circuit.

GENERAL

This section describes trouble analysis routine, calibration and test procedures that are useful for servicing the Lambda power supply. A trouble chart is provided as an aid for the troubleshooter. Refer to the section on SPECIFICATIONS AND FEATURES for the minimum performance standards.

TROUBLE ANALYSIS

Whenever trouble occurs, systematically check all fuses, primary power lines, external circuit elements, and external wiring for malfunction before troubleshooting the equipment. Failures and malfunctions often can be traced to simple causes such as improper jumpers and supply-load connections or fuse failure due to metal fatigue.

Use the electrical schematic diagram and block diagram, figure 8, as an aid to locating trouble causes. The schematic diagram contains various circuit voltages that are averages for normal no load operation. Measure these voltages using the conditions for measurement specified on the schematic diagram. Use measuring probes carefully to avoid causing short circuits and damaging circuit components.

CHECKING TRANSISTORS AND CAPACITORS

Check transistors with an in-circuit transistor checker. If no checker is available, transistors can be checked with an ohmmeter that has a highly limited current capability. Observe proper polarity for PNP or NPN to avoid error in measurement. The forward transistor resistance is low but never ZERO; backward resistance is always higher than the forward resistance.

Do not assume trouble is eliminated when only one part is replaced. This is especially true when one transistor fails, causing other transistors to fail. Replacing only one transistor and turning power on, before checking for additional faulty components could damage the replaced component.

When soldering semi-conductor devices, hold the lead being soldered with a pair of pliers or a commercial heat sink device placed between the component and the solder joint.

NOTE: The leakage resistance obtained from a simple resistance check of a capacitor is not always an indication of a faulty capacitor. In all cases the capacitors are shunted with resistances, some of which have low values. Only a dead short is a true indication of a shorted capacitor.

PRINTED CIRCUIT BOARD MAINTENANCE TECHNIQUES

1. If foil is intact, but not covered with solder, it is a good contact. Do not attempt to cover with solder.

2. Voltage measurements can be made from either side of the board. Use a needle-point probe to penetrate to the wiring whenever a protective coating is used on the wiring. A brass probe can be soldered to an alligator clip adapted to measuring instrument.

3. Always use a heat sink when soldering transistors; a transistor pad with mounting feet is an effective heat sink.

4. Broken or damaged printed wiring is usually the result of an imperfection, strain or careless soldering. To repair small breaks, tin a short piece of hook-up wire to bridge the break, and holding the wire in place, flow solder along the length of wire so that it becomes part of the circuitry.

5. When unsoldering components from the board never pry or force loose the part; unsolder the component by using the wicking process described below:

   a) Select a 3/16 inch tinned copper braid for use as a wick; if braid is not available, select AWG No. 14 or No. 16 stranded wire with 1/2 inch insulation removed.

b) Dip the wick in liquid rosin flux.

c) Place the wick onto the soldered connection and apply soldering iron onto the wick.

d) When sufficient amount of solder flows onto the wick, freeing the component, simultaneously remove iron and wick.

ROUBLE CHART

The trouble chart is intended as a guide for locating trouble causes and is used along with the schematic agram.

The operating conditions assumed for the trouble chart are as follows:

a) AC power of proper voltage and frequency is present at input terminals.

b) Either positive or negative terminal is connected to chassis ground.

c) The power supply is connected for constant voltage with local sensing. See schematic; dotted lines indicate jumpers connected for local sensing operation.

SAFETY NOTICE

ANGEROUS VOLTAGES EXIST IN THIS EQUIPMENT. OBSERVE THE USUAL SAFETY PRE-AUTIONS WHEN OPERATING OR SERVICING THE EQUIPMENT TO AVOID SHOCK OR INJURY.

TROUBLE SHOOTING CHART

Symptom	Possible Cause	Remedy
1. Zero volts DC output, no-waveform between collector of Q12 and negative of C5.	Open F1. Defective Q2 thru Q5.	Check and replace as necessary.
2. Same as 1, waveform between collector of Q12 and negative of C5 is correct, voltage across C19 is zero or too low.	Defective CR25 thru CR28. Defective Q14, Q15.	Check and replace as necessary.
3. Same as 2, voltage across C19 is correct, no-waveform between A2-8 and -S (GND).	Defective A1, A2. Defective CR29 thru CR34.	Check and replace as necessary.
4. Same as 3, waveform between A2-8 and -S(GND) is correct, no-waveform between A3-3 and -S(GND).	Defective A3, A4, A5.	Replace as required.
5. Same as 4, waveform between A3-3 and -S(GND) is correct, voltage across A2-2 to -S(GND) is too low.	Disconnected wire at terminals RV1 to RV2.	Reconnect as required.
	Defective A6.	Check voltage across C37, if voltage across C37 is correct, replace A6 as required.
	Defective SCR.	Check and replace as necessary.
	Defective OV module MP-1.	Replace as required.

TROUBLE SHOOTING CHART

Symptom	Possible Cause	Remedy
6. Same as 5, voltage across A2-2 to -S is correct, no-waveform between A1-6 to -S.	Defective A1, A2. Defective Q14, Q15.	Check and replace as necessary.
7. Same as 6, waveform A1-6 to -S is correct, no-waveform between collector of Q14 and -S.	Defective Q14, Q15.	Check and replace as necessary.
8. Same as 7, waveform between collector of Q14 and -S is correct, no-waveform between anode of CR51 and -S.	Defective Q2 thru Q5.	Check and replace as necessary.
9. Output DC voltage is too low.	Defective CR45.	Check and replace as necessary.
10. R2 is very hot under full load.	Defective CR11 thru CR14.	Check and replace as necessary.
11. Defective current limiting.	Defective CR44. Defective A4, A5.	Check and replace as necessary.
12. DC output unregulated.	Defective A4.	Replace as required.

PERFORMANCE CHECKS

Check the ripple and regulation of the power supply using the test connection diagram shown in figure 9. Use suggested test equipment or equivalent to obtain accurate results. Refer to SPECIFICATIONS AND FEATURES for minimum performance standards.

Set the differential meter, DC DVM (John Fluke Model 891A or equivalent) to the selected power supply operating voltage. Check the power supply load regulation accuracy while switching from the no load to load condition. Long load leads should be a twisted pair to minimize AC pick-up.

Use a Variac to vary the line voltage from 187-265 or 265-187 volts AC and check the power supply line regulation accuracy on the DVM differential meter.

Use a VTVM John Fluke Model 931B or equivalent, to measure rms ripple voltage of the power supply DC output. Use oscilloscope to measure peak-to-peak ripple voltage of the power supply DC output.

ADJUSTMENT OF CALIBRATION CONTROLS VR2, VR3

Whenever voltage and current indications do not reflect maximum ratings, adjust VR2 and VR3 as follows. The adjustment procedure requires that the power supply is removed from associated equipment, is at an ambient temperature of 25-30°C, and is stabilized and not operating.

1. Remove AC input power to the supply.
2. Break seal on wiper of VR3 from resistor housing and turn to full CCW position.
3. Operate power supply for constant voltage with local sensing connected as shown in figure 3, with no external load, and with AC input of 200 VAC, 50 Hz.
4. Turn voltage adjust control until minimum rated output voltage is obtained.
5. Apply load so that output current is 110-115% of 50°C rating for the unit.
6. Using a differential meter, DC DVM (John Fluke Model 891A or equivalent), observe output voltage while adjusting VR3 in CW direction. Adjust VR3 until output voltage drops.
7. Remove AC power input to the supply.
8. Break seal on wiper of VR2 from resistor housing.
9. Operate power supply for constant voltage with remote sensing connected as shown in figure 4, with AC input 200 VAC, 50 Hz.
10. Adjust VR1 to the same operating point as described above.
11. Repeat steps 3 through 10 until no further adjustment is required.
12. After adjustment is completed, remove AC input power to the supply and reseal wipers of VR2 and VR3.

SERVICE

When additional instructions are required or repair service is desired, contact the nearest Lambda office where trained personnel and complete facilities are ready to assist you.

Please include the power supply model and serial number together with complete details of the problem. On receipt of this information, Lambda will supply service data or advise shipping for factory repair service.

All repairs not covered by the warranty will be billed at cost and an estimate forwarded for approval before work is started.

PARTS ORDERING

Standard components and special components used in the Lambda power supply can be obtained from the factory. In case of emergency, critical spare parts are available through any Lambda office.

The following information must be included when ordering parts:

1. Model number and serial number of power supply and purchase date.
2. Lambda part number.
3. Description of part together with circuit designation.
4. If part is not electronic part, or is not listed, provide a description, function, and location, of the part.

PARTS LIST

The electrical parts located on Lambda models LJS-10-5-V-OV — LJS-10-28-V-OV are listed here. Parts common to a group of models are listed first. Unique parts of individual models within the group are listed separately, by model, immediately following the group common parts listing.

COMMON PARTS
MODELS LJS-10-5-V-OV — LJS-10-28-V-OV

CIRC. DESIG.	DESCRIPTION	LAMBDA NO.
A1	Integrated circuit	FBT-00-104
A2	Integrated circuit	FBT-00-105
A3	Integrated circuit	FBT-00-111
A4	Integrated circuit	FBT-00-112
A5	Integrated circuit	FBT-00-113
A6	Optical amplifier	FBT-00-107
C1, C2	Cap., ceramic, 4,700 pf -20+80%, 2,000 vdc	CDK-47-016
C3, C4	Cap., metalized polyester film, 0.01 mf ±20%, 630 vdc	CGL-10-020
C5, C6	Cap., elect., 100 mf -10+50%, 450 vdc	CBR-10-182
C7	Cap., elect., 10 mf -10+50%, 450 vdc	CBP-10-113
C8	Cap., ceramic, 680 pf ±10%, 2,000 vdc	CDJ-68-012
C9	Cap., elect., 100 mf -10+50%, 63 vdc	CBR-10-139
C10	Cap., polyester film, 2,200 pf ±10%, 100 vdc	CGK-22-011
C11	Cap., elect., 10 mf -10+50%, 50 vdc	CBP-10-097
C12, C13	Cap., polyester film, 3,300 pf ±10%, 100 vdc	CGK-33-012
C14 thru C17	Cap., ceramic, 270 pf ±10%, 500 vdc	CDJ-27-011
C18	Cap., polyester film, 4,700 pf ±10%, 100 vdc	CGK-47-015
C19, C20	Cap., elect., 100 mf -10+50%, 10 vdc	CBR-10-172
C21, C22	Cap., ceramic, 0.1 mf -20+80%, 50 vdc	CDM-10-004
C23, C24	Not assigned	
C25	Cap., elect., 47 mf -10+50%, 10 vdc	CBP-47-109
C26	Cap., polyester film, 0.022 mf ±10%, 100 vdc	CGL-22-027
C27	Cap., ceramic, 10 pf ±10%, 50 vdc	CDH-10-005
C28	Cap., polyester film, 0.01 mf ±10%, 100 vdc	CGL-10-021
C29	Same as C25	
C30	Same as C21	
C31	Cap., elect., 0.47 mf -10+50%, 50 vdc	CBM-47-007
C32	Same as C18	
C33	Same as C26	
C34	Not assigned	
C35	Same as C25	

COMMON PARTS (Cont.)
MODELS LJS-10-5-V-OV — LJS-10-28-V-OV (Cont.)

CIRC. DESIG.	DESCRIPTION	LAMBDA NO.
C36	Not assigned	
C37	Same as C25	
C44	Cap., metalized polyester film, 0.22 mf ±20%, 100 vdc	CAM-22-028
C46, C47	Cap., metalized polyester film, 0.1 mf ±20%, 250 vdc	CGM-10-025
C48, C49	Cap., metalized polyester film, 0.01 mf ±20%, 630 vdc	CGL-10-020
C50	Same as C46	
C400	Cap., polypropylene, 0.47 mf ±10%, 400 vdc	CKM-47-003
CR1-CR4	Rectifier	FBL-00-171
CR5, CR6	Rectifier	FBL-00-162
CR7 thru CR10		FBL-00-173
CR11 thru CR14	Rectifier	FBL-00-155
CR15, CR16	Rectifier, zener diode	FBM-Z169
CR17 thru CR24	Rectifier	FBL-00-127
CR25 thru CR28	Same as CR11	
CR29 thru CR43	Rectifier	FBL-00-128
CR44, CR45	Rectifier, zener diode	FBM-Z170
CR46	Same as CR11	
CR47-CR50	Same as CR29	
F1	Fuse, 4A, 250V	F520-OV-000-1
F1	Fuse, 3A, 3AG, 250V	F520-03-000-1*
L1, L2	Choke	BBA-JS12V-1
CUR. XFMR	Same as L1	
L3	Choke	BBA-JS10V-1
L4, L5	Choke	BBA-JS10V-2
L6	Choke	BBA-JS12V-3

*Only used on units with serial no. prefixes A thru C.

COMMON PARTS (Cont.)
MODELS LJS-10-5-V-OV — LJS-10-28-V-OV (Cont.)

CIRC. DESIG.	DESCRIPTION	LAMBDA NO.
Q1	Transistor, NPN	FBN-L184
Q2 thru Q5	Transistor, NPN	FBN-L205
Q6	Transistor, NPN	FBN-L185
Q7, Q8	Transistor, NPN	FBN-L208
Q9 thru Q12	Transistor, NPN	FBN-L206
Q13	Transistor, PNP	FBN-L207
Q14, Q15	Same as Q9	
Q16, Q17	Same as Q7	
R1	Res., ww, 680 ohms ±5%, 10 w	DER-68-016
R2	Res., film, 51,000 ohms ±5%, 5 w	DCT-51-099
R3 thru R6	Res., carbon film, 20 ohms ±5%, 1/4 w	DBP-20-006
R7 thru R10	Res., carbon film, 51 ohms ±5%, 1/4 w	DBP-51-003
R11 thru R13	Res., ww, 0.22 ohms ±5%, 2 w	DEM-22-007
R14	Thermistor, 300 ohms ±15%, 25°C	DKR-30-005
R15	Res., carbon film, 10 ohms ±5%, 1/4 w	DBP-10-002
R16	Not assigned	
R17	Res., film, 1,500 ohms ±5%, 4 w	DCS-15-128
R18	Res., carbon film, 5.1 ohms ±5%, 1/2 w	DBN-51-001
R19	Res., carbon film, 3,900 ohms ±5%, 1/4 w	DBS-39-001
R20	Res., carbon film, 5,600 ohms ±5%, 1/4 w	DBS-56-002
R21	Res., carbon film, 7,500 ohms ±5%, 1/4 w	DBS-75-003
R22, R23	Not assigned	
R24, R25	Res., carbon film, 12,000 ohms ±5%, 1/4 w	DBT-12-001
R26, R27	Res., carbon film, 5,100 ohms ±5%, 1/4 w	DBS-51-004
R28, R29	Res., carbon film, 15,000 ohms ±5%, 1/4 w	DBT-15-002
R30, R31	Same as R24	
R32, R33	Res., carbon film, 27,000 ohms ±5%, 1/4 w	DBT-27-003
R34	Same as R7	

COMMON PARTS (Cont.)
MODELS LJS-10-5-V-OV — LJS-10-28-V-OV (Cont.)

CIRC. DESIG.	DESCRIPTION	LAMBDA NO.
R35, R36	Res., carbon film, 220 ohms ±5%, 1/4 w	DBR-22-002
R37	Res., carbon film, 470 ohms ±5%, 1/4 w	DBR-47-003
R38	Not assigned	
R39	Same as R26	
R40	Res., carbon film, 910 ohms, ±5%, 1/4 w	DBR-91-004
R41	Same as R37	
R42 thru R44	Not assigned	
R45	Res., carbon film, 620 ohms ±5%, 1/4 w	DBR-62-005
R46	Res., carbon film, 100 ohms ±5%, 1/4 w	DBR-10-006
R47	Res., carbon film, 100 ohms ±5%, 1/2 w	DBR-10-001
R48	Res., carbon film, 390 ohms ±5%, 1/4 w	DBR-30-007
R49	Res., carbon film, 2,000 ohms ±5%, 1/4 w	DBS-20-005
R50	Res., carbon film, 200 ohms ±5%, 1/4 w	DBR-20-008
R51	Res., carbon film, 300 ohms ±5%, 1/4 w	DBR-30-009
R52, R53	Same as R37	
R54, R55	Res., carbon film, 820 ohms ±5%, 1/4 w	DBR-82-010
R56, R57	Not assigned	
R58	Res., carbon film, 5.1 ohms ±5%, 1/4 w	DBN-51-003
R59	Not assigned	
R60, R61	Same as R46	
R62	Res., carbon film, 240 ohms ±5%, 1/4 w	DBR-24-011
R63	Res., carbon film, 150 ohms ±5%, 1/4 w	DBR-15-012
R64	Same as R50	
R65	Res., carbon film, 2,200 ohms ±5%, 1/4 w	DBS-22-006
R66	Res., carbon film, 43 ohms ±5%, 1/4 w	DBP-43-004
R67, R68	Same as R46	
R69	Res., carbon film, 1,300 ohms ±5%, 1/4 w	DBS-13-013
R70, R71	Same as R48	
R72	Res., carbon film, 1,000 ohms ±5%, 1/4 w	DBS-10-008

COMMON PARTS (Cont.)
MODELS LJS-10-5-V-OV — LJS-10-28-V-OV (Cont.)

CIRC. DESIG.	DESCRIPTION	LAMBDA NO.
73, 74	Same as R7	
75	Same as R19	
76	Same as R35	
77	Same as R37	
78	Same as R14	
80	Not assigned	
83	Res., carbon film, 3,000 ohms ±5%, 1/4 w	DBS-30-015
84	Not assigned	
85	Same as R48	
86	Res., carbon film, 6,800 ohms ±5%, 1/4 w	DBS-68-017
CR 2	Rectifier, silicon controlled	FBP-00-053
T2	Transformer	ABA-JS12V -1
T3	Transformer	ABA-JS12V -2
VR2, VR3	Res., var., cermet, 100 ohms ±20%, 1/2 w	DRR-10-015
VR4	Res., var., cermet, 5,000 ohms ±20%, 3/4 w	DRS-50-028

UNIQUE PARTS
MODEL LJS-10-5-V-OV

C38 thru C40	Cap., polyester film, 4,700 pf ±10%, 100 vdc	CGK-47-015
C41	Cap., elect., 1,000 mf -10+50%, 10 vdc	CBS-10-178
C42, C43	Cap., elect, 2,200 mf -10+50%, 10 vdc	CBS-22-138
C45	Cap., elect., 100 mf -10+50%, 10 vdc	CBR-10-172
CR51, CR52	Rectifier	FBL-00-172* FBL-00-189
MP-1	Protector, overvoltage	L-12-OV-5
R79	Res., carbon film, 3,300 ohms ±5%, 1/4 w	DBS-33-009
R81	Res., carbon film, 1,600 ohms ±5%, 1/4 w	DBS-16-016
R82	Res., carbon film, 1,100 ohms ±5%, 1/4 w	DBS-11-012
R87 thru R89	Res., ww, 51 ohms ±5%, 1/2 w	DBP-51-001
R90	Res., ww, 51 ohms ±5%, 2 w	DFP-51-072
SHO	Shunt	ESP-30-018
T1	Transformer	ABA-LJS10V -5

UNIQUE PARTS (Cont.)
MODEL LJS-10-6-V-OV

CIRC. DESIG.	DESCRIPTION	LAMBDA NO.
C38 thru C40	Cap., polyester film, 4,700 pf ±10%, 100 vdc	CGK-47-015
C41	Cap., elect., 1,000 mf -10+50%, 10 vdc	CBS-10-178
C42, C43	Cap., elect., 2,200 mf -10+50%, 10 vdc	CBS-22-138
C45	Cap., elect., 100 mf -10+50%, 10 vdc	CBR-10-172
CR51, CR52	Rectifier	FBL-00-172* FBL-00-189
MP-1	Protector, overvoltage	L-12-OV-6
R79	Res., carbon film, 4,300 ohms ±5%, 1/4 w	DBS-43-010
R81	Res., carbon film, 1,800 ohms ±5%, 1/4 w	DBS-18-014
R82	Res., carbon film, 1,100 ohms ±5%, 1/4 w	DBS-11-012
R87 thru R89	Res., ww, 51 ohms ±5%, 1/4 w	DBP-51-001
R90	Res., ww, 51 ohms ±5%, 2 w	DFP-51-072
SHO	Shunt	ESP-30-018
T1	Transformer	ABA-LJS10V -6

MODEL LJS-10-12-V-OV

C38 thru C40	Cap., ceramic, 4,700 pf ±10%, 500 vdc	CDK-47-018
C41	Cap., elect., 330 mf -10+50%, 25 vdc	CBR-33-173
C42, C43	Cap., elect., 470 mf -10+50%, 25 vdc	CBR-47-140
C45	Cap., elect., 33 mf -10+50%, 25 vdc	CBP-33-106
CR51, CR52	Rectifier	FBL-00-131* FBL-00-177
MP-1	Protector, overvoltage	L-12-OV-12
R79	Res., carbon film, 9,100 ohms ±5%, 1/4 w	DBS-91-011
R81	Res., carbon film, 7,500 ohms ±5%, 1/4 w	DBS-75-003
R82	Res., carbon film, 1,300 ohms ±5%, 1/4 w	DBS-13-013
R87 thru R89	Res., ww, 51 ohms ±5%, 1 w	DFP-51-073
R90	Res., ww, 300 ohms ±5%, 2 w	DFR-30-126
T1	Transformer	ABA-LJS10V -12

* Only used on units with serial no. prefixes A and B.

UNIQUE PARTS (Cont.)
MODEL LJS-10-15-V-OV

CIRC. DESIG.	DESCRIPTION	LAMBDA NO.
C38 thru C40	Cap., ceramic 4,700 pf ±10%, 500 vdc	CDK-47-018
C41	Cap., elect., 330 mf -10+50%, 25 vdc	CBR-33-173
C42, C43	Cap., elect., 470 mf -10+50%, 25 vdc	CBR-47-140
C45	Cap., elect., 33 mf -10+50%, 25 vdc	CBP-33-106
CR51, CR52	Rectifier	FBL-00-131* FBL-00-177
MP-1	Protector, overvoltage	L-12-OV-15
R79	Res., carbon film, 12,000 ohms ±5%, 1/4 w	DBT-12-001
R81	Same as R79	
R82	Res., carbon film, 1,300 ohms ±5%, 1/4 w	DBS-13-013
R87 thru R89	Res., ww, 51 ohms ±5%, 1 w	DFP-51-073
R90	Res., ww, 360 ohms ±5%, 2 w	DFR-36-127
T1	Transformer	ABA-LJS10V -15

MODEL LJS-10-20-V-OV

C38 thru C40	Cap., ceramic, 4,700 pf ±10%, 500 vdc	CDK-47-018
C41	Cap., elect., 220 mf -10+50%, 35 vdc	CBR-22-174
C42, C43	Cap., elect., 470 mf -10+50%, 35 vdc	CBR-47-141
C45	Cap., elect., 22 mf -10+50%, 35 vdc	CBP-22-107
CR51, CR52	Rectifier	FBL-00-132* FBL-00-178
MP-1	Protector, overvoltage	L-12-OV-20
R79	Res., carbon film, 16,000 ohms ±5%, 1/4 w	DBT-16-004
R81	Res., carbon film, 27,000 ohms ±5%, 1/4 w	DBT-27-003
R82	Res., carbon film, 1,800 ohms ±5%, 1/4 w	DBS-18-014
R87 thru R89	Res., ww, 51 ohms ±5%, 1 w	DFP-51-073
R90	Res., ww, 620 ohms ±5%, 2 w	DER-62-128
T1	Transformer	ABA-LJS10V -20

*Only used on units with serial no. prefixes A and B.

UNIQUE PARTS (Cont.)
MODEL LJS-10-24-V-OV

CIRC. DESIG.	DESCRIPTION	LAMBDA NO.
C38 thru C40	Cap., ceramic, 4,700 pf ±10%, 500 vdc	CDK-47-018
C41	Cap., elect., 220 mf -10+50%, 35 vdc	CBR-22-174
C42, C43	Cap., elect., 470 mf -10+50%, 35 vdc	CBR-47-141
C45	Cap., elect., 22 mf -10+50%, 35 vdc	CBP-22-107
CR51, CR52	Rectifier	FBL-00-132* FBL-00-178
MP-1	Protector, overvoltage	L-12-OV-24
R79	Res., carbon film, 20,000 ohms ±5%, 1/4 w	DBT-20-005
R81	Res., carbon film, 43,000 ohms ±5%, 1/4 w	DBT-43-007
R82	Res., carbon film, 1,800 ohms ±5%, 1/4 w	DBS-18-014
R87	Res., ww, 51 ohms ±5%, 2 w	DFP-51-072
R88, R89	Res., ww, 51 ohms ±5%, 1 w	DFP-51-073
R90	Res., ww, 910 ohms ±5%, 2 w	DFR-91-129
T1	Transformer	ABA-LJS10V -24

MODEL LJS-10-28-V-OV

C38 thru C40	Cap., ceramic, 4,700 pf ±10%, 500 vdc	CDK-47-018
C41	Cap., elect., 100 mf -10+50%, 50 vdc	CBR-10-179
C42, C43	Cap., elect., 330 mf -10+50%, 50 vdc	CBR-33-142
C45	Cap., elect., 10 mf -10+50%, 50 vdc	CBP-10-097
CR51, CR52	Rectifier	FBL-00-132* FBL-00-178
MP-1	Protector, overvoltage	L-12-OV-28
R79	Res., carbon film, 24,000 ohms ±5%, 1/4 w	DBT-24-006
R81	Res., carbon film, 91,000 ohms ±5%, 1/4 w	DBT-91-008
R82	Res., carbon film, 1,800 ohms ±5%, 1/4 w	DBS-18-014
R87	Res., ww, 51 ohms ±5%, 2 w	DFP-51-072
R88, R89	Res., ww, 51 ohms ±5%, 1 w	DFP-51-073
R90	Res., ww, 1,200 ohms ±5%, 2 w	DFS-12-097
T1	Transformer	ABA-LJS10V -28

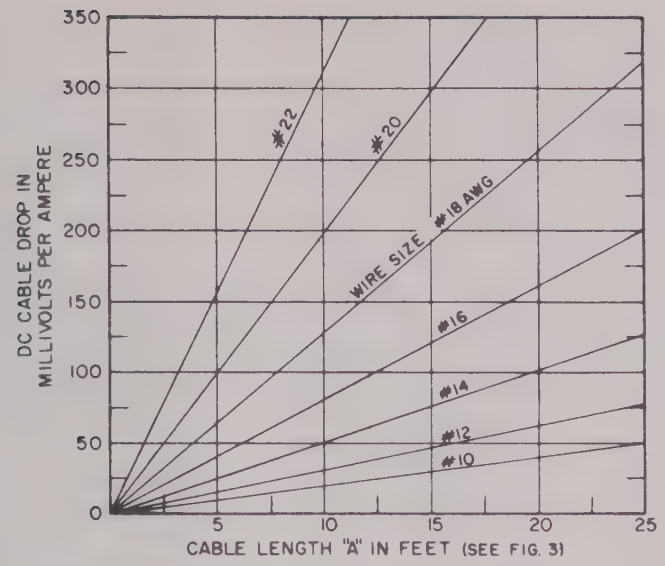


Figure 1. Cable Connection Chart.

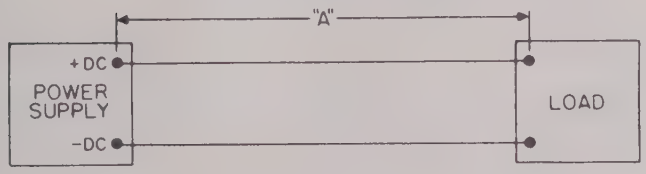


Figure 2. Cable Length "A" in Feet.

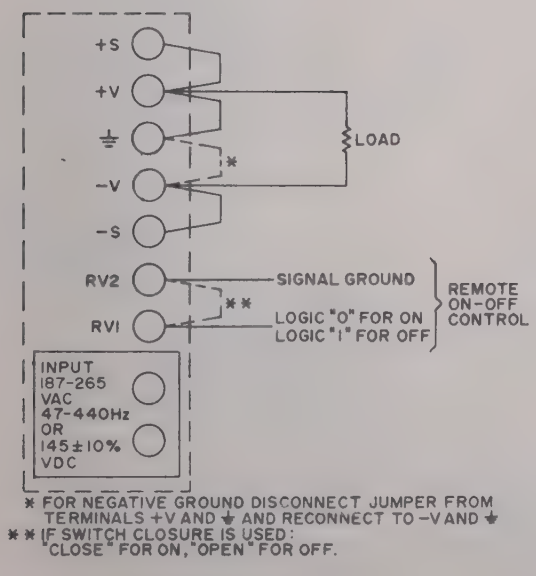


Figure 3. Local Sensing Connections.

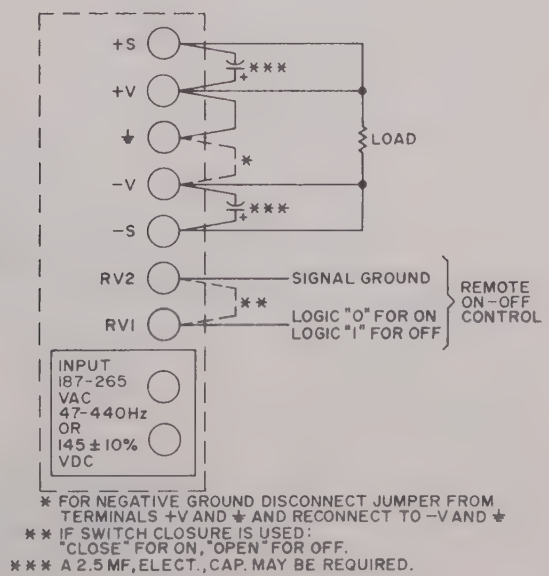


Figure 4. Remote Sensing Connections.

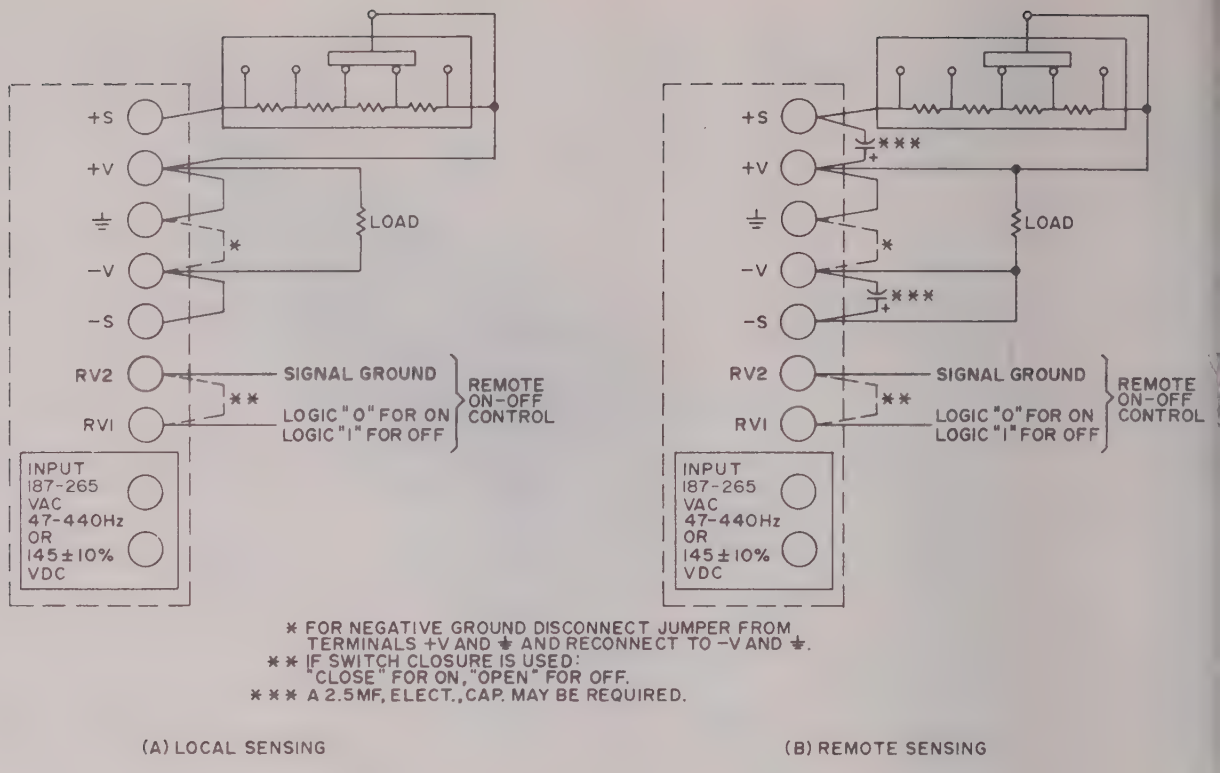


Figure 5. Programmed Voltage, With External Resistor.

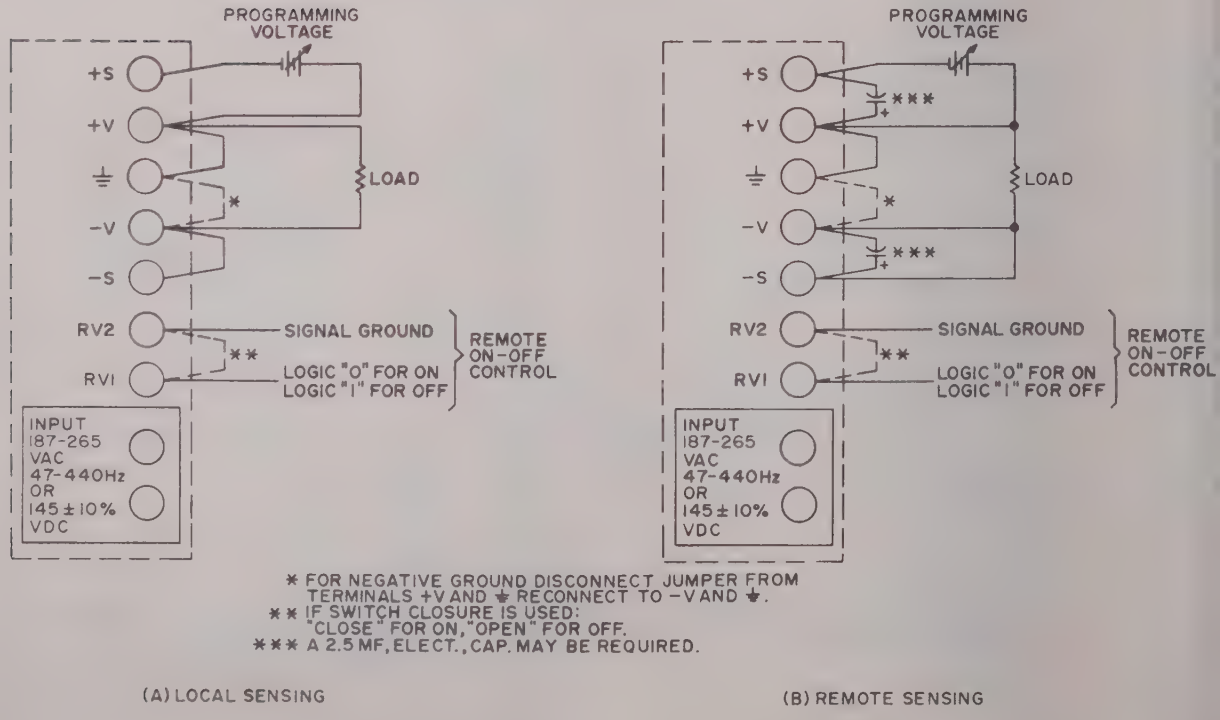


Figure 6. Programmed Voltage, with External Programming Voltage Source.

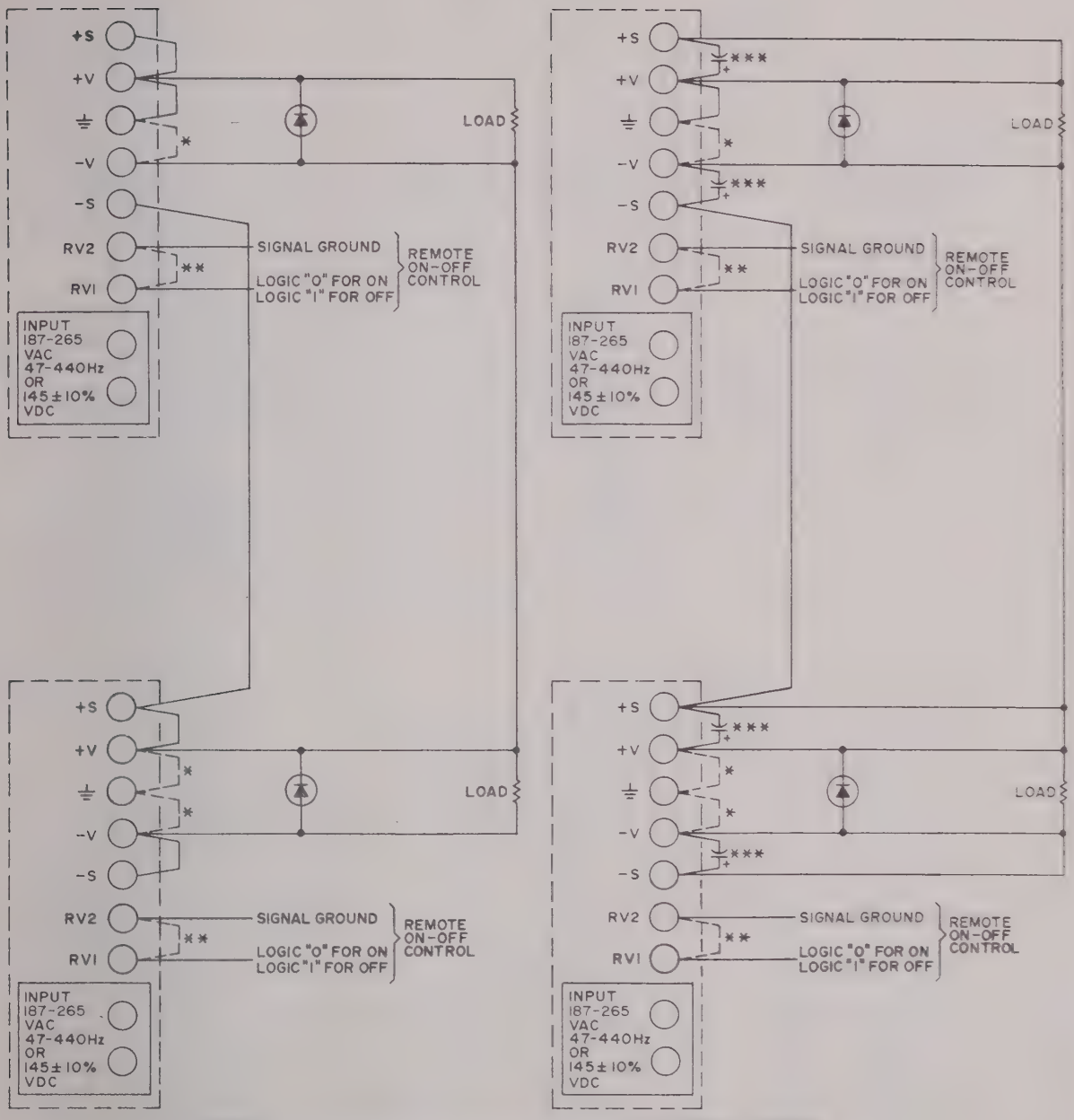

+S
+V
-V
-S
RV2
RVI
LOAD
SIGNAL GROUND
LOGIC "0" FOR ON
LOGIC "1" FOR OFF
REMOTE ON-OFF CONTROL
INPUT
187-265 VAC
47-440Hz
OR
145±10% VDC
(A) LOCAL SENSING
(B) REMOTE SENSING
* MAKE ONLY ONE GROUND CONNECTION FOR SERIES COMBINATION. TO CHANGE GROUND AS SHOWN, REMOVE JUMPER FROM TERMINALS +V AND ⏚ ON TOP UNIT AND CONNECT ANY ONE OF THE OTHER JUMPERS AS SHOWN IN DOTTED LINE.
** IF SWITCH CLOSURE IS USED: "OPEN" FOR ON, "CLOSES" FOR OFF.
*** A 2.5MF, ELECT., CAP. MAY BE REQUIRED.

Figure 7. Series Connection.

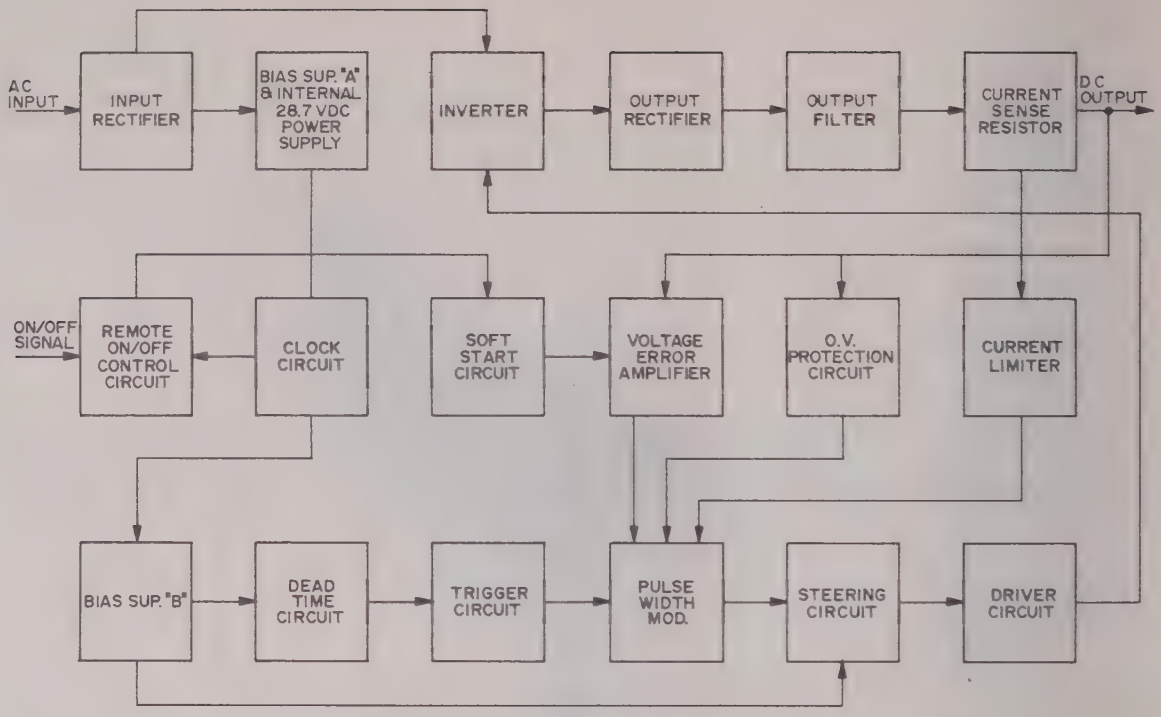


Figure 8. Typical Block Diagram.

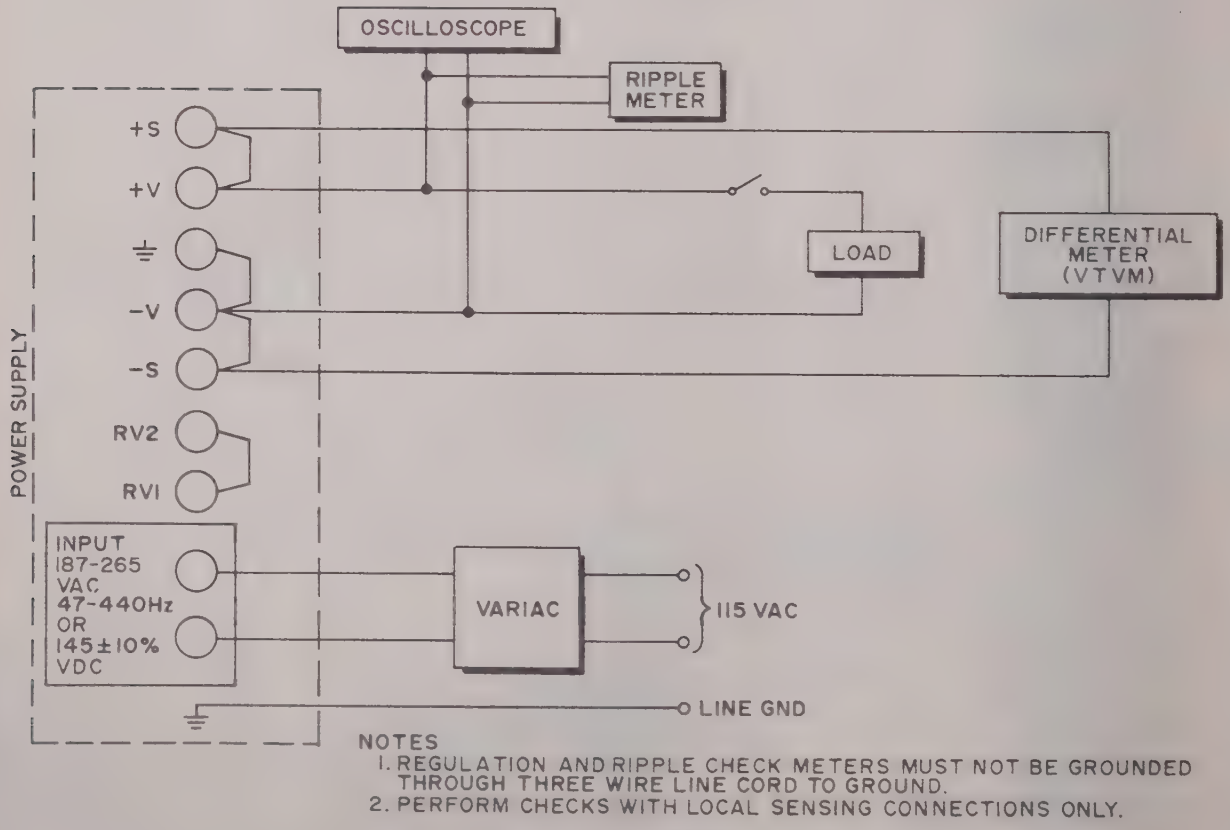


Figure 9. Test Connections for Performance Checks.

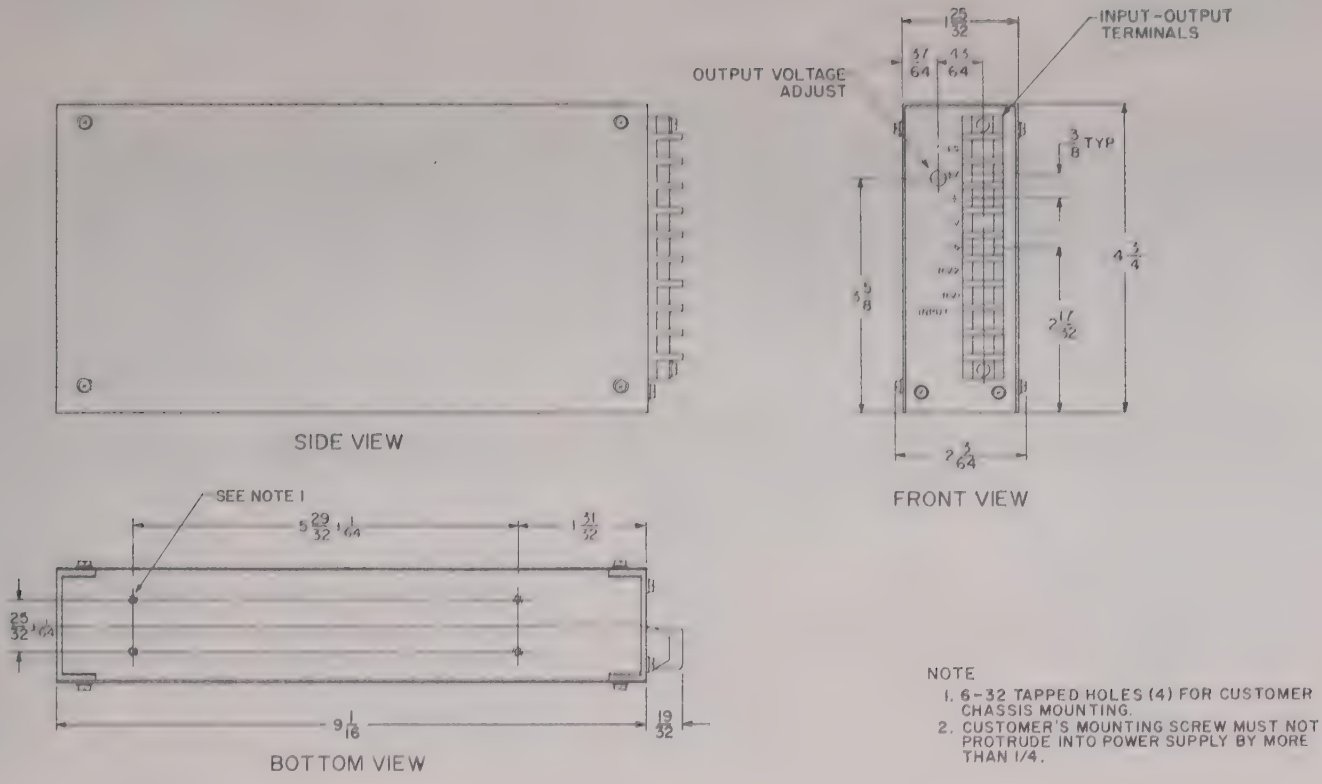
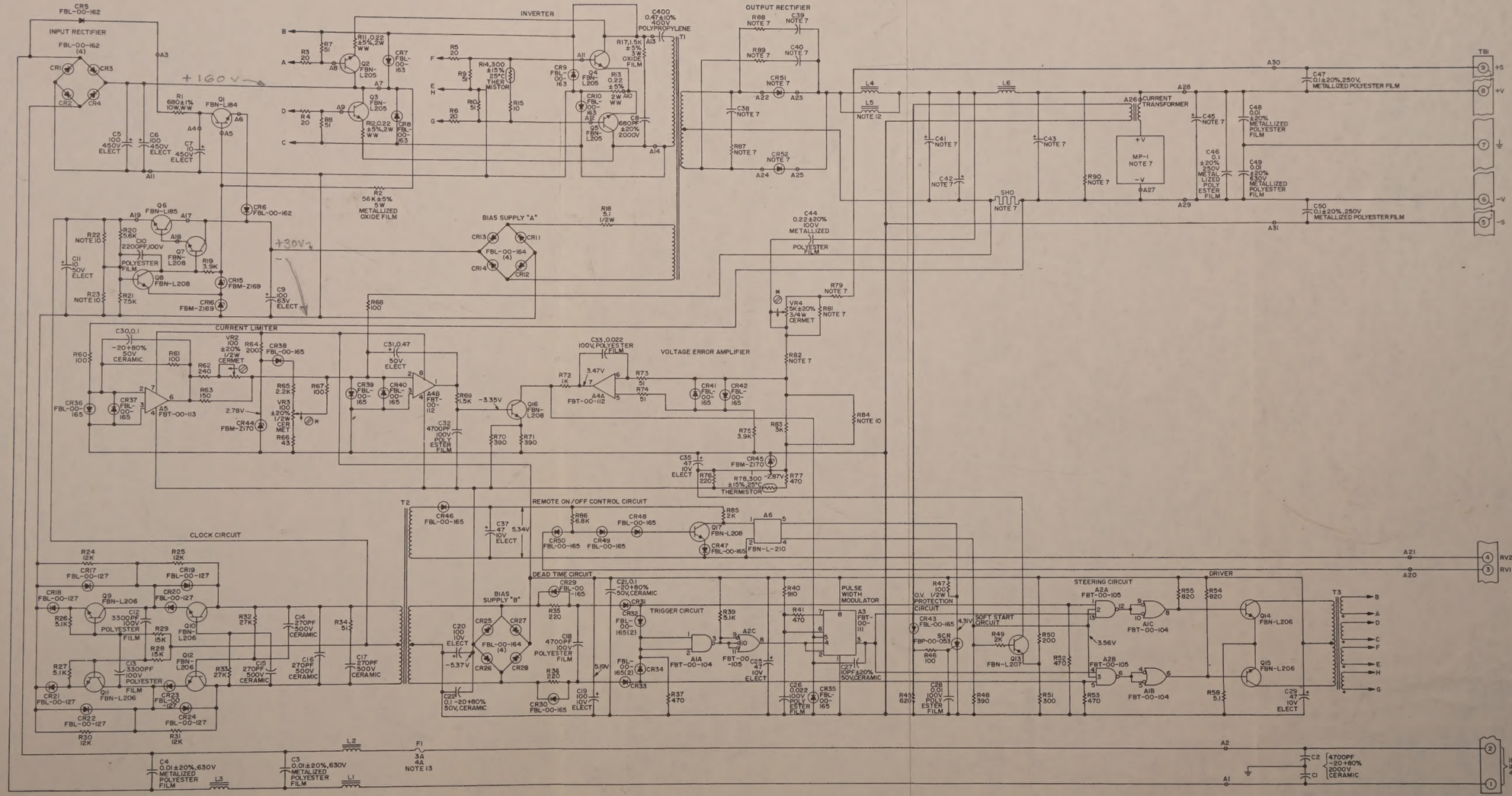


Figure 10. Outline Drawing.

TABLE I
SCHEMATIC DATA REFERENCES
MODELS LJS-10-5-V-OV THROUGH LJS-10-28-V-OV

Model	C38 C39 C40	C41	C42 C43	C45	CR51 CR52		MP-1	R79	R81	R82	R87	R88 R89	R90	SH-0
	±10% CERAMIC	-10+50% ELECT.	-10+50% ELECT.	-10+50% ELECT.	FBL-00-*		L-12-OV-* OV-PROTEC	±5%, 1/4W CARBON FILM	±5%, 1/4W CARBON FILM	±5%, 1/4W CARBON FILM	±5% CARBON FILM	±5% 1W WW	±5% 2W WW	ESP-30-* SHUNT
LJS-10-5-V-OV	4,700 pf 100 vdc POLY- FILM	1,000 mf 10 vdc	2,200 mf 10 vdc	100 mf 10 vdc	172†	189	5	3.3K	1.6K	1.1K	51 1/2W	51, 1/2W CARBON FILM	51	018
LJS-10-6-V-OV	4,700 pf 100 vdc POLY- FILM	1,000 mf 10 vdc	2,200 mf 10 vdc	100 mf 10 vdc	172†	189	6	4.3K	1.8K	1.1K	51 1/2W	51, 1/2W CARBON FILM	51	018
LJS-10-12-V-OV	4,700 pf 500 vdc	330 mf 25 vdc	470 mf 25 vdc	33 mf 25 vdc	131†	177	12	9.1K	7.5K	1.3K	51 1W	51	300	NOT USED
LJS-10-15-V-OV	4,700 pf 500 vdc	330 mf 25 vdc	470 mf 25 vdc	33 mf 25 vdc	131†	177	15	12.0K	12.0K	1.3K	51 1W	51	360	NOT USED
LJS-10-20-V-OV	4,700 pf 500 vdc	220 mf 35 vdc	470 mf 35 vdc	22 mf 35 vdc	132†	178	20	16.0K	27.0K	1.8K	51 1W	51	620	NOT USED
LJS-10-24-V-OV	4,700 pf 500 vdc	220 mf 35 vdc	470 mf 35 vdc	22 mf 35 vdc	132†	178	24	20.0K	43.0K	1.8K	51 2W	51	910	NOT USED
LJS-10-28-V-OV	4,700 pf 500 vdc	100 mf 50 vdc	330 mf 50 vdc	10 mf 50 vdc	132†	178	28	24.0K	91.0K	1.8K	51 2W	51	1.2K	NOT USED

*Lambda part number
†Only used on units with serial no. prefixes A and B



NOTES

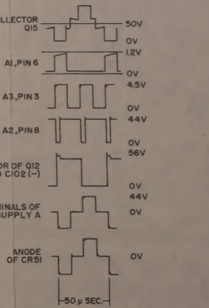
1. RESISTORS ARE 1/4W CARBON FILM WITH VALUES IN OHMS UNLESS OTHERWISE NOTED.
2. CAPACITOR VALUES ARE IN MICROFARADS UNLESS OTHERWISE NOTED.
3. RESISTOR TOLERANCES: CARBON FILM ±5%, WIREWOUND ±5% UNLESS OTHERWISE NOTED.
4. CAPACITOR TOLERANCES: ELECTROLYTIC -10+50%, CERAMIC ±10%, POLYESTER FILM ±10%, METALLIZED POLYESTER FILM ±10% UNLESS OTHERWISE NOTED.
5. SYMBOLS:
   - ▭ INDICATES ACTUAL UNIT MARKING.
   - ↓ INDICATES CLOCKWISE ROTATION OF SHAFT.
   - ✱ SEE INSTRUCTION MANUAL.
   - ⊘ INDICATES ADJUSTMENT OR CALIBRATION CONTROL.
   - -o- INDICATES TERMINAL ON PRINTED WIRING BOARD OR TERMINAL BOARD. TERMINALS WITH "A" DESIGNATIONS ARE ON THE "A" BOARD. TERMINALS WITH "B" DESIGNATIONS ARE ON THE "B" BOARD.
6. DESIGNATIONS ARE LAMBDA PART NUMBERS.
7. SEE TABLE I FOR COMPONENT VALUES.
8. SEE TABLE I FOR VOLTAGE VALUES.
9. CONDITIONS FOR CIRCUIT POINT MEASUREMENTS: INPUT: 220VAC, 47-440Hz. OUTPUT: NOMINAL VOLTAGE, FULL LOAD, +S AND +V SHORTED, -S AND -V SHORTED. INDICATED VOLTAGES ARE TYPICAL VALUES AND ARE DC UNLESS OTHERWISE NOTED. DC MEASUREMENTS TAKEN WITH 20,000 OHMS/V VOLTMETER. AC MEASUREMENTS ARE PEAK VALUES MEASURED WITH OSCILLOSCOPE. VOLTAGES ARE TAKEN BETWEEN INDICATED POINTS AND -S (TERM. 7) UNLESS OTHERWISE NOTED.
10. THESE COMPONENTS ARE SELECTED IN TEST AND CAN VARY FROM UNIT TO UNIT, OR IN SOME CASES MAY NOT BE USED AT ALL. REFER TO TABLE II FOR SPECIFIC COMPONENT VALUES APPLICABLE TO THE COMPONENTS OF THE UNIT IN USE.

TABLE II

RESISTOR VALUE *
20,000
24,000
27,000
30,000
36,000
43,000
51,000
62,000
75,000
82,000
91,000
100,000
150,000
200,000
240,000
300,000

* RESISTORS ARE CARBON FILM 1/4WATT ±5% UNLESS OTHERWISE NOTED.

11. THE FOLLOWING WAVEFORMS, TAKEN UNDER FULL LOAD CONDITIONS, CAN BE OBSERVED BETWEEN INDICATED POINTS AND -SENSE UNLESS OTHERWISE NOTED, AND ARE TYPICAL VALUES.



12. L5 IS CONNECTED IN SERIES WITH L4 ON MODELS LJS-10-V-20-0V, 24-0V AND 28-0V. L5 NOT USED ON 20V, 24V AND 28V UNITS WITH SERIAL NO. PREFIX A.
13. 3A FUSE ONLY USED ON UNITS WITH SERIAL NO. PREFIXES A-C.

FOR WIRING OF POWER SUPPLY TO LOAD REFER TO SUPPLY-TO-LOAD WIRING DIAGRAMS.

DOTTED CONNECTIONS SHOWN ON TB1 INDICATE JUMPERS IN PLACE FOR LOCAL SENSING CONNECTION.

THIS SCHEMATIC APPLIES TO UNIT BEARING SERIAL NO PREFIXES A-D

SCHEMATIC DIAGRAM
REGULATED POWER SUPPLY

MODELS
LJS-10-V-5-0V
LJS-10-V-6-0V
LJS-10-V-12-0V
LJS-10-V-15-0V
LJS-10-V-20-0V
LJS-10-V-24-0V
LJS-10-V-28-0V

LAMBDA
ELECTRONICS
MELVILLE, NEW YORK
DIVISION OF VERCO INSTRUMENTS INC.

5-Year
Guarantee
We warrant each instrument manufactured by us, and sold by us or our authorized agents, to be free from defects in material and workmanship, and that it will perform within applicable specifications for a period of five years after original shipment. Our obligation under this guarantee is limited to repairing or replacing any instrument or part thereof, (except tubes and fuses) which shall, within five years after delivery to the original purchaser, be returned to us with transportation charges prepaid, prove after our examination to be thus defective.
We reserve the right to discontinue instruments without notice, and to make modifications in design at any time without incurring any obligation to make such modifications to instruments previously sold.

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